# SIMIODE EXPO 2023 Detailed Schedule

## Day 1: 10 February 2023 (Eastern US Time)

### Day 1 - 12:45 PM– 1:00 PM (Main Room) Opening Ceremony and Greetings

### Day 1 - 1:00 PM–1:25 PM Modeling Opportunities

- (Main Room) Karl Havlak and Thi Thu Huang Vo, Angelo State University, San Angelo TX USA *Simulating a Predator-Prey System with a Lotka-Volterra Model Using Random Coefficients Estimated from a Data Set*

  **Abstract:**The Lotka-Volterra predator-prey model is a classic differential equation model that is used to simulate idealized predator-prey interactions. Applying the model to actual predator-prey populations is challenging because idealized habitats likely do not exist, so data for validating the model is difficult to find. In this presentation, data generated by Brend Blasius, Lars Rudolf, Guntram Weithoff, Ursula Gaedke, and Gregor Fussmann in a controlled environment on the growth of rotifers and algae is used to approximate the coefficients in the Lotka-Volterra model. A pseudo-stochastic approach is then applied whereby the coefficients are allowed to vary randomly at fixed timesteps where the coefficients are selected from intervals determined from the data. The results are mixed with some well-behaved simulation results obtained and some that were not realistic. It is clear that the coefficients for the interaction terms in the model need to be more precisely approximated as small changes in those coefficients often result in unrealistic outcome.

- (Room 1) Maila B. Hallare, United States Air Force Academy, USAFA CO USA *Battle of the Smartphone Brands: Will One Drive the other to Extinction?*

  **Abstract:**The Bass Model is a first-order nonlinear differential equation that models the diffusion of a product or an innovation using parameters that capture the markets' spontaneous innovation and imitation. Created in 1979 by Frank Bass, this model is still currently being used in sales forecasting and in making management decisions on pricing and advertising.
  In this talk, we consider a two-dimensional system of differential equations with the Bass Model in the growth component of the model and with interaction terms that capture competition between two products. The resulting system is used to analyze the interaction between the top two smartphone brands. In particular, we would like to know if the mathematical ecology result called Competitive Exclusion Principle applies to the resulting system. Competitive Exclusion Principle predicts that there is a state wherein one product drives the competition to extinction.

- (Room 2) France Caron, Shophika Vaithyanathasarma, Geneviève Bistodeau-Gagnon, and Jacques Bélair, Université de Montréal, Montréal Québec CANADA *Bringing Back The People in Modeling Epidemics*

  **Abstract:** The emergence of COVID-19 favored the development at Université de Montréal of an educational initiative aimed at promoting modeling and simulation in teaching and learning postsecondary mathematics. In particular, compartmental epidemiological models were the subject of activities with digital tools (Insight Maker and Excel) that generated interest among teachers and students. We later realized the value of considering the significant effects of nonpharmaceutical interventions (NPI), the social divide that occurs in the face of mandated measures and the effect on this divide of the perceptions of the message relayed in the media.
  A study carried out on these aspects, based on data collected in Québec, led us to develop a new activity, which enriches the models to be built and explored by students. This work leads to considering a social dimension to the teaching of modeling with differential equations and to include this teaching in the development of critical thinking.
  We will present the goals of the modeling initiative for students, the approach for developing learning activities with Insight Maker as both a modeling and learning environment, the first activities developed, and the feedback received from instructors about using such activities to teach differential equations. After a quick review of the study documenting the variable degree of adherence of the population to the measures imposed, we will end with the enrichment of the models for the new learning activity.

## Day 1 - 1:30 PM–1:55 PM Organization Sources

- (Main Room) Jack Picciuto, COMAP, Bedford MA USA *The Consortium for Mathematics and its Application – An Overview of COMAP and What We Do*

  **Abstract:**The Consortium for Mathematics and its Application (COMAP) was founded in 1980 to work with teachers, students, and industry to create learning environments where mathematics is used to model real issues in our world. COMAP runs several international math modeling competitions at the middle school, high school, and undergrad levels. In 2022, over 28,000 student teams competed. We publish/edit math journals and texts, and have a large resource of student and teaching modeling modules online.

- (Room 1) Beverly West, CODEE, Ithaca NY USA *Sharing News and Offerings of CODEE*

  **Abstract:** We discuss the creation of CODEE (Community of Ordinary Differential Equations Educators) 31 years ago, its purpose, its current state, and its great symbiotic relationship with SIMIODE. Together we provide a rich source of modeling opportunities, an enlarged community, and new opportunities. CODEE is currently updating our website list of Resources for the benefit of all. We are also preparing a new Special Issue (Engaging the World: Differential Equations Aid Public Policy) of the online *CODEE Journal*, which has an amazing global impact we want to tell you about.

## Day 1 - 2:00 PM–2:25 PM: Get to Know Colleague Attendees

We provide Break Out rooms with 5 attendees assigned randomly so attendees can get to know some other attendees and exchange interests.

## Day 1 - 2:30 PM–3:25 PM (Main Room) Keynote Speaker

- Lorelei Koss, Mathematics, Dickinson College, Carlisle PA USA *Connecting Differential Equations with the Arts, Music, and Literature*

  **Abstract:**This talk aims to survey a variety of ways that ideas from differential equations can be connected to the creation, performance, or analysis of works in the arts and humanities. The main goal of this project is to engage students (or others!) with relevant and interesting material from the arts and humanities and increase their appreciation of those subjects. We discuss how differential equation models provide a different lens for students with strong mathematical backgrounds to approach other disciplines.

## Day 1 - 3:30 PM–3:55 PM Breakout Time on Topics

- (Main Room) Moderator Lorelei Koss, Mathematics, Dickinson College, Carlisle PA USA *Connecting Differential Equations with the Arts, Music, and Literature*

  **Abstract:** Bring your ideas and critiques. How might you reach out to non-STEM areas such as the arts, music, and literature with differential equations? Learn through sharing and discussions.

- (Room 1) Panel and Discussion on Prison Math Project (PMP) -- Participants include Ben Jeffers, Volunteer Coordinator-PMP, Trinity University, San Antonio TX US; Jeff Calhoun, Modules Team Leader-PMP, University of Colorado, Boulder CO USA; Nolan Adams, Nonprofit Development Specialist, University of North Texas, Denton TX USA; Jake Thiry, Mentor Communications-PMP, Redwood Christian High School, San Lorenzo CA USA; Carrie Fulton, Social Media Manager-PMP, University of Colorado, Boulder CO USA.
  Organized by Christopher Havens, Founding Director of the Prison Math Project. *Prison Math Project - Mentoring and Learning*

  **Abstract:** Meet leaders of The Prison Math Project (PMP) and hear about how you might get involved as a mentor to an incarcerated member of our society and engage in mathematical conversations. Some members of PMP are learning mathematics and others are teaching mathematics.

  References

  1. Shell-Gellasch, Amy. 2022. The Prison Mathematics Project – Bridging the Gap. *MAA FOCUS*. October/November 2022. 12-13.
  2. Rubio, Mario, Simone Sisneros-Thiry, Thomas Stromblad Jr., Joshua Wen, and Nicole Norena Yamzon. Integrating Communities through Limits and Fun-ctions: Teaching and Learning Calculus in Prison. *MAA FOCUS*.October/November 2022. 12-13. 24-27 .
  3. Waite, Jesse. 2022. Math on the Inside. *MAA FOCUS*. December/January. 24-27.

- (Room 2) Moderator: Kurt Bryan, Mathematics, Rose-Hulman Institute of Technology, Terre Haute IN USA. Panel: Faculty - Jared Bunn, Florida Polytechnic University, Lakeland FL USA and Ala' J. Alnaser, Florida Polytechnic University, Lakeland FL USA; and Student - Ani Unzueta, Florida Polytechnic University, Lakeland FL USA
  *Meet the Author of SIMIODE's Textbook, Differential Equations: A Toolbox for Modeling the World*

**Abstract:** Get overview of the intent and opportunities in this exciting modeling first, low-cost text and hear from faculty and students who have used the text to motivate teaching and learning differential equations through the rich tapestry of modeling offered by the text.

## Day 1 - 4:00 PM–4:25 PM Role of Technology and Tools in Modeling - I

- (Main Room) Virgil Ganescu, Mathematics, York College of Pennsylvania, York PA USA *Multisim - a Circuit Simulator*

  **Abstract:**Multisim software, as applicable to validating differential equations centric models, is introduced. Multisim integrates industry-standard SPICE code simulation with an interactive schematic environment to instantly visualize and analyze electronic circuit behavior. In this presentation MultiSim is used to validate the theoretical models of two small signal electronic circuits, governed by first order and second order ODEs, respectively.

- (Room 1) Ryan C Cooper, University of Connecticut, Storrs CT USA *Project-Based Engineering with Jupyter and Python*

  **Abstract:** In this talk, I will share my experiential teaching philosophy and technology stack that I use to build project-based courses in Jupyter. Students are excited by these developments and love the interactivity of Jupyter notebook projects, readings, and assignments. I have five project-based courses shared through github via my website. I will highlight my improvement of student evaluation of teaching scores and individual student success stories.

- (Room 2) Andrew Miller, Belmont University, Nashville TN USA *SageMathCell as a DE Toolbox*

  **Abstract:** SageMath, as a free, open-source, Python-based computer algebra system, is a wonderful tool for differential equations courses. Unfortunately, there are still barriers to entry: learning syntax is difficult for students, and if one does not install one's own Sage server locally, students need a paid subscription to a Sage server in the cloud for full notebook functionality. In teaching differential equations courses over the last few years, I have found a useful middle ground: Creating permanent links to cells on the SageMathCell server (https://sagecell.sagemath.org/) with editable code to perform frequent ODE computing tasks. I will show how a set of these links creates a DE toolbox with student and discuss the advantages and disadvantages of this approach.

## Day 1 - 4:30 PM–4:55 PM Role of Technology and Tools in Modeling - II

- (Main Room) Tim Lucas, Mathematics, Pepperdine University, Malibu CA USA and Krista Lucas, Biology, Pepperdine University, Malibu CA USA *Slopes: A Free, Intuitive Mobile App to Enhance Learning in Differential Equations*

  **Abstract:** In a differential equations course it is crucial for mathematics students to engage in active learning along with discussion of the material with their peers. A key for these students to understand mathematical models that incorporate differential equations is visualizing slopefields, phase planes and solutions. *Slopes* is a mobile application with an intuitive interface that is designed to visualize solutions to differential equations and support active learning in the classroom. *Slopes* is currently available for iPads, iPhones, and Android phones, which are highly portable and feature larger touch screens that

allow students to view and manipulate content easily. To study the possible benefits of the app, we implemented group activities using *Slopes* into an ordinary differential equations class, conducted observations and focus groups, and examined final poster projects on modeling topics. We found that students used *Slopes* to visualize solutions, aid in discussion and cooperation, and demonstrate understanding of differential equations concepts. This session will engage participants in group activities that introduce classes of differential equations through mathematical models, provide opportunities for visual exploration, and encourage discussion of the concepts in the context of the models.

- (Room 1) Sami Kanderian, WikiModel LLC, Germantown MD USA *A Web-based Software Application that Enables Teachers, Students, Scientists and Engineers to Simulate, Fit and Share Mathematical Models*

  **Abstract:** Today, the creation, simulation, and fitting of mathematical model equations, particularly those with Ordinary Differential Equations are done with different programming languages, each with their own syntax. This can be a stumbling block to young students who are just trying to learn mathematical modeling concepts but lack the programming knowledge, or have bugs in the code that prevent them from generating the correct simulated output. Furthermore, models that have discrete inputs at specific times must be explicitly programmed to start and stop at each of these time steps as ODE integration routines such as Runge-Kutta have an adaptive time step. Fitting the model parameters to experimental data adds an additional level of complexity with an iterative, non-linear least squares fitting routine programmed in a separate script outside the model definition.

  WikiModel, a web-based program was created to alleviate these stumbling blocks for students who just want to learn mathematics and see how model outputs behave quickly and easily. Here, a set of custom model equations are entered in a table as they would appear in a math text book. Model parameter values are entered in another table and the model is simulated with the click of a “Simulate” button. Discrete inputs and the times in which they occur can be entered in another table. The model can also be fit to experimental data entered in another table with a “Fit” button. Desired state variables are selected from a drop down to be output in one or more plots.

- (Room 2) Phil Gustafson, Colorado Mesa University, Grand Junction CO USA *Jupyter Notebook and RMarkdown in a Modeling Based Differential Equations Course*

  **Abstract:**The Jupyter Notebook and R Markdown document environments can be used to write and execute program code as well as create documents incorporating text formatting (Markdown), mathematics formatting (LaTeX) and programming code. These attributes provide an effective working environment and are useful in creating integrated written reports in a modeling based differential equations course.
  Jupyter Notebook is seemingly better known in the numerical mathematics community because of its close connection with Python, whereas R Markdown is found within RStudio and is often associated with statistics. However, RMarkdown offers a convenient workspace and can compile a variety of programming languages, including Python, Octave, and R. Further, RMarkdown has the ability to export documents to several different formats (including Word), allowing for high quality written reports and instructional handouts. In this talk we compare and contrast Jupyter Notebook and RMarkdown, outline their basic features, and illustrate how they can play an important role in a modeling based differential equations course.

## Day 1 - 5:00 PM–5:25 PM  Calculus and Differential Equation Modeling - I

- (Main Room) Jennie D'Ambroise, SUNY Old Westbury, Old Westbury NY USA *Adapting SIMIODE Modeling Scenarios for Calculus*

  **Abstract:** In this talk we will review two examples of modeling projects that were adapted from existing SIMIODE scenarios. The adapted lab projects are designed for Calculus I students with virtually no additional preparatory lecture needed aside from standard Calculus I material. The projects take a modeling first approach in order to help students discover the basics of differential equations through modeling. Each project includes basic components of a typical differential equations lecture that the students see for the first time within the modeling project. This talk will focus on the pedagogical approach of adapting existing SIMIODE scenarios, with mindfulness towards an unforgiving required syllabus schedule for your Calculus class. As this approach is evolving, participants will have the opportunity to give feedback on the presenter's new ideas for the Spring semester.

- (Room 1, Part I) Frank Wattenberg, United States Military Academy (Emeritus), West Point NY USA *Humanities/Social Sciences - Differential Equations: One Course in a Lifetime of Modeling*

  **Abstract:**Modeling is essential for understanding and bettering our lives. Recent advances - e.g, more powerful and soon quantum computers, large data, ML/AI and new analogies, like quantum phenomena, have dramatically enlarged our modeling repertoire and toolkit. This interactive session focuses on modeling with differential equations in this new context. Resources for the talk.

- (Room 2) Adhvaith Sridhar and Peter Xu, University of Minnesota Twin Cities, Minneapolis MN USA *SIRV Model for the Prediction of H5N1 Influenza Case Count and Geotemporal Spread*

  **Abstract:** An outbreak of a highly contagious pandemic influenza virus has started in avian species around the United States. Avian influenza, also known as bird flu, is a zoonotic infection that can spread to humans. Specifically, the H5N1 strain of the Avian influenza is the cause of the current outbreak. It is thought that poultry farms were infected by migratory birds carrying the disease. Outbreaks of this flu variant could lead to significant economic loss and a public health crisis. It is imperative to slow the transmission of the virus and mitigate the serious consequences of the outbreak. However, any public health response requires a well-informed origin in order to enable the efficient allocation of resources to regions that require them most and in a way that ensures the stop of the spread of cases.
  In order to enable the generation of accurate predictions that may be used to inform decisions about resource allocation and spread management, we have developed a SIRV model to predict, along with a geotemporal spread pattern, the number of infected individuals, vaccinations, and other metrics in the case of a human outbreak.

## Day 1 - 5:30 PM–5:55 PM  Calculus and Differential Equation Modeling - II

- (Main Room) Victoria Rayskin, Haverford College, Haverford PA USA *Using Discrete Dynamical Systems and Differential Equations Projects in Calculus II*

  **Abstract:** Our non-traditional Calculus II course motivates integration through the study of Discrete Dynamical Systems and Differential Equations. Each of the 2 sections (DDS

and DE) culminates with a project on COVID-19 corresponding model. I will discuss various students' approaches for the projects, utilization of technology tools, and the work flow.

- (Room 1, Part II) Frank Wattenberg, United States Military Academy (Emeritus), West Point NY USA *Discussions: One Course in a Lifetime of Modeling*

  **Abstract:** We continue the theme of Part I in discussion mode for all to participate with their experiences and ideas.

- (Room 2) Allan Struthers, Michigan Technological University, Houghton MI USA *Experiments, Data and Models for Nonlinear Electrical Circuits*

  **Abstract:** The presentation will describe a sequence of simple experiments built on breadboard using standard passive (resistors, capacitors, and inductors) circuit components and a commodity analog multiplier chip. Data is collected using an inexepensive digital oscilliscope (we used FNIRSI 1014D currently available for $172 US dollars on Ebay) with a built-in signal generator. Data is exported from the oscilloscope and compared to simple model predictions using Mathematica.
  The first set of experiments are the simple LR, RC, and LRC circuits considered in most ODE texts. The agreement with the standard models is of course extremely good but perhaps more interestingly the standard signal generator wave forms available on a modern signal generator provide a natural way to extract parameter values from the data.
  The second set of experiments are intended to introduce the analog multiplier chip (we used AD633 chips available for $4 US dollars each on Ebay) and convince the audience that the chip returns a voltage that is the scaled product of two input voltage differences.
  The final experiment incorporates multiplier chips in LRC circuits to generate more interesting output.

## Day 1 - 6:00 PM–7:30 PM: Meal Break

## Day 1 - 7:30 PM–7:55 PM: Big Picture Issues

- (Main Room) Victor Donnay, Bryn Mawr College, Bryn Mawr PA USA *Discovering Bifurcation*

  **Abstract:**The world is facing a wide range of ecological challenges, including species extinction and the climate crisis. The mathematical concept of a bifurcation point underlies many of these phenomena and hence is an important topic for our students to understand. This concept has found its way into popular culture, where it is referred to as a “tipping point.”
  In this session, we share a cooperative learning lesson based on the jig-saw technique in which students build on their knowledge of phase line diagrams to discover for themselves the notion of bifurcation point and diagram. The bifurcation in question occurs in a one-parameter family of differential equations that model harvesting fish: the logistic equation with harvesting.
  Reference:
  Victor Donnay. 2013. Using sustainability to incorporate service-learning into a mathematics course: a case study. *PRIMUS* Special issue on Service Learning 23(6): 519-537.

- (Room 1) Tracy Weyand, Rose-Hulman Institute of Technology, Terre Haute IN USA *Engaging Engineers by Design*

  **Abstract:** As future scientists and engineers, my students will be expected to use their knowledge and technical skills to make accurate predictions that will then influence and justify design decisions. Many of these predications will stem from mathematical models. In this talk, I will discuss how I stimulate interest in differential equations by providing opportunities for my students to practice making design decisions. I will focus on a project that requires students to design a building that will not collapse during an earthquake.

## Day 1 - 8:00 PM–8:25 PM: Sources and Examples of Models

- (Main Room) Michael A. Karls, Ball State University, Muncie IN USA *Cooking a Turkey*

  **Abstract:** The goal of this project is to investigate several models for the cooking time for a turkey based on weight, test these models with data obtained from heating curves for turkeys of various weights, and develop a new model to this data. This is a SIMIODE Modeling Scenario in detail and will be immediately usable by attendees.

- (Room 1) Glenn Ledder, University of Nebraska-Lincoln, Lincoln NE USA *Mathematical Modeling for Epidemiology and Ecology*

  **Abstract:** *Mathematical Modeling for Epidemiology and Ecology* is a forthcoming book to be published by Springer-Verlag. The book is comprised of two parts: Part 1 with three chapters on modeling and Part 2 with three chapters on dynamical system analysis. The biological content is self-contained and includes a variety of topics. Some of this material appears in case studies that focus on a single detailed example, and some is based on recent research by the author on vaccination modeling and scenarios from the COVID-19 pandemic.

  The problem sets feature linked problems where one biological setting appears in multi-step problems that are sorted into the appropriate section, allowing readers to gradually develop complete investigations of specific models. Some problems use programs written by the author for Matlab or Octave; these combine with more traditional mathematical exercises to give students a full set of tools for model analysis. Each chapter contains additional case studies in the form of projects with detailed directions.

  This talk will begin with an overview of the contents of the book. I will then show some of the non-standard features in the chapters on mechanistic modeling and on dynamical system analysis.

## Day 1 - 8:30 PM–8:55 PM: Some History and Geometry

- (Main Room) Jacob M. Manale, University of South Africa, Pretoria, Gauteng SOUTH AFRICA *The Logic of the World's Most Famous Identity* $e^{(i\pi)}=-1$

  **Abstract:**The identity $e^{(i\pi)}=-1$ is world famous for relating the numbers $e$, $\pi$, $i$ and 1 together. We believe the expression is not entirely accurate. We begin by reproducing the steps Euler followed to obtain this expression, and point out where his logic breaks down. After that we use a differential equation to show that the correct expression is $e^{(i\pi)}=-1$.

- (Room 1) Yagub Aliyev, ADA Univ. Baku AZERBAIJAN *Engineering/Physics - Interception Curves*

  **Abstract:**There are many interesting curves on the plane or the sphere which are defined mechanically or geometrically and can be studied using differential equations. For example, on the plane one can consider Tractrix and Pursuit Curve, while on the sphere one can consider the Loxodrome also known as a Rhumb line. The two curves studied in the current presentation seem to be undeservedly less known and one of them even new.

  As an example, suppose that two points P and Q, initially at O(0, 0) and A(1, 0), respectively, move with constant and equal velocity, so that Q is on the line x = 1 and P is on the ray OQ. What curve is defined by the point P? We answer and generalize this question.

## Day 1 - 9:00 PM–until: Free Time

The conference platform will be open for informal self-directed conversations and Zoom meetings.

# Day 2: 11 February 2023 (Eastern US Time)

## Day 2 - 12:45 PM–1:00 PM: (Main Room) Opening Greeting

## Day 2 - 1:00 PM–1:25 PM: SCUDEM

- (Main Room) Anthony Stefan, Florida Institute of Technology, Melbourne FL USA USA *The SCUDEM Experience: Overview, Progress, and Future Directions*

  **Abstract:**We share a brief introduction to SCUDEM from top to bottom; its purpose and opportunity, history, format, participation, results, etc. What does SCUDEM offer student participants, coaches, and judges? What practical activities can teams and coaches do to prepare for the SCUDEM Challenge? What can participation in SCUDEM mean after SCUDEM?

## Day 2 - 1:30 PM–1:55 PM: SCUDEM Experiences

- (Main Room) Vincent Earl Andrews, Emily Happy, and Emma Sandidge, Florida Institute of Technology, Melbourne FL USA USA *Outstanding Team: Modeling the Mechanics of Suction Feeding*

  **Abstract:** In the Fall of 2022, we participated in a global differential equations modeling challenge SCUDEM VII hosted by SIMIODE, where we received the highest distinction - Outstanding Award. Our goal was to develop a model to mimic jaw movement of Actinopterygian fish to pull water and prey into its mouth for feeding. In this talk, we would like to introduce the SCUDEM challenge, present our model, the feedback we received from the judges, and share how this experience benefited each of us. See Outstanding Team video posted at SIMIODE's Youtube Channel.

- (Room 1) Damon Spencer, Morgan Kortlander, Natalie Pham, University of Houston, Houston TX USA *Outstanding Team: Modeling People Ruin Everything*

  **Abstract:** We participated in the SCUDEM VII Challenge and made a model for the People Ruin Everything problem. The People Ruin Everything problem describes an ecosystem of animals that is exposed to human activity, and asks participants to model the trends of the system over time. Our work for the problem (available on SIMIODE's YouTube channel) received an outstanding award. In this presentation we share our model, experiences creating the model, our feedback from the judges, and what we gained from participating in SCUDEM VII.

- (Room 2) Sebastian Neumann, Noah Hale, Zoe Winston, United States Military Academy, West Point NY USA *Outstanding Team: Recovering from Disruption -- Modeling Human Introduction to an Isolated System*

  **Abstract:** In the Fall of 2022, we participated in SCUDEM, a global differential equation modeling challenge run by SIMIODE. The prompt we chose to answer was entitled "People Ruin Everything" and focused on how humans affect existing predator-prey equilibriums. Modifying the existing Lotka-Volterra population modeling equations, we accounted for human entry into and exit from an isolated ecosystem, looking specifically at predator-prey relationships. We found that, while the system does reach an equilibrium following the exit of humans, the animal populations suffer permanent effects from human entry and exit.

## Day 2 - 2:00 PM–2:25 PM: Using SIMIODE and Other Published Sources

- (Main Room) Fabiana Zama, University of Bologna, Bologna ITALY *An Introduction to Modelling Through a Microbial interaction Application*

  **Abstract:** This talk presents an example of a modelling project from microbial interaction models reported in a recent research paper [1]. The target students belong to a Numerical Methods course for the master's degree in Applied Mathematics at the University of Bologna. In general, they possess quite a strong background in Mathematical Analysis and differential equations from a theoretical point of view. However, they need to learn how such models are used in real applications, which numerical strategies are to be applied, and how to discuss the computed results.

  The first step is reading the paper, understanding the proposed models and checking the reproducibility of some reported results. Then they define synthetic data using the parameters reported in the paper to investigate the estimation of the parameters by measuring the sensitivity to noise and the choice of the initial data. In this regard, it is required to implement in a Matlab script the Levenberg-Marquardt with the gradient computed by the adjoint-state method. This topic interested students who greatly appreciated the opportunity to come into contact with a real application.

  References

  [1] B Kuchen, YP Maturano, RM Gil, F Vazquez, and GJE Scaglia. 2022. Kinetics and mathematical model of killer/sensitive interaction under different physicochemical conditions of must/wine: a study from a biological point of view. *Letters in Applied Microbiology*. 74(5):718–728.

- (Room 1) Vinodh Chellamuthu, Utah Tech University, Saint George UT USA *Increasing STEM Students Retention Rates Using Mathematical Modeling in Curriculum Design*

  **Abstract:** In this presentation, I will discuss a preliminary study examining how connecting differential equations concepts to real-world scenarios through mathematical modeling helps enhance students' confidence in their mathematical abilities and increases STEM major's retention rates. The primary goal of this study is to assess how mathematical modeling activities helped students see the value and positive perspectives towards STEM disciplines. In particular, the presentation will highlight feedback on how engaging students in contextualized efforts through mathematical modeling can provide rich and motivating learning experiences for students.

## Day 2 - 2:30 PM–2:55 PM: Large Source Materials

- (Main Room) Glenn Ledder, University of Nebraska-Lincoln, Lincoln NE USA *Using Linked Problem Sets to Embed Modeling into a Differential Equations Course*

  **Abstract:** The forthcoming book, *Mathematical Modeling for Epidemiology and Ecology*, features linked problems where one biological setting appears in multi-step problems that are sorted into the appropriate section, allowing readers to gradually develop complete investigations of specific models. Some problems use programs written by the author for Matlab or Octave; these combine with more traditional mathematical exercises to give students a full set of tools for model analysis. These linked problem sets can be used as multi-part projects in a differential equations class.

In this talk, we will examine two sets of linked problems. One is a consumer-resource model for phytoplankton and zooplankton. The model has several equilibria whose stability depends on regions in the parameter space. The second set will be an SIR epidemiological model that includes loss of immunity. Both linked problem sets include model building followed by dynamical system analysis using nullcline, eigenvalues, and the Routh-Hurwitz conditions.

- (Room 1) Joseph DiStefano III, University of California, Los Angeles CA USA *Challenges of Teaching Dynamic System Modeling to Undergrads in Diverse Disciplines*

  **Abstract:** Subtitle: Modeling for Life Scientists: Appreciating and Learning It
  This talk will address experiences of the presenter in over 57 years of teaching modeling to various groups of students. We discuss how we bring together the multidisciplinary pedagogy of life sciences and mathematics into a single introductory modeling methodology course, crystalizing the experience of an author who has been teaching dynamic biosystems modeling and simulation methodology for the life sciences. We offer examples of modelin with differential equations. We show how to explore a more rigorous treatment of introductory mechanistic life science math modeling integrated with biology.

  Reference
  1. DiStefano, Joseph, III. 2023. *Dynamic Biosystem Modeling and Simulation Methodology: Integrated and Accessible*. Third Edition: Color Enhanced Education Version. Academic Press. Cambridge MA USA.

## Day 2 - 3:00 PM–3:55 PM: (Main Room) Keynote Speaker

- Anuj Mubayi, Center for Collaborative Studies in Mathematical Biology, Illinois State University, Normal IL USA Real World Evidence Solutions, IQVIA, USA; 4820 Emperor Blvd, Durham NC USA; and Kalam Institute of Health Technology, Government of India, Visakhapatnam INDIA. *It's About Packaged Wisdom: A Journey from Being a Mathematician to Becoming a Scientist Via Modeling World*

  **Abstract:** In this talk, Dr. Mubayi will use examples from his professional background and highlight his achievements as an applied mathematician. He will touch base on his experiences in his pedagogical training and mentoring practices while working in infectious disease modeling, quantitative social science, and global health economics. Dr. Mubayi will also provide information about his professional career as a scientist in the healthcare industry. He will share lessons learned that may be useful to participants as they carve their professional pathways.

## Day 2 - 4:00 PM–4:25 PM: Using SIMIODE and Other Published Sources

- (Main Room) Kathryn Kozak, Coconino Community College, Flagstaff AZ USA *Using SIMIODE and Other Published Sources of Modeling in Differential Equations*

  **Abstract:**Would you like to use activities in your class, but you don't know where to start? This presentation will outline which activities are used in the presenter's class. In class these activities are used in multiple ways.
  First there are activities that are used as an introduction to a topic as a guided class discussion. The class works together on the topic so the students can determine some of the nuances of the course.
  The second use is as active learning activities in groups. The activities are given to the

groups that are assigned randomly, and the members of the group work together to determine a solution to the problem. The groups share with each other so that all students learn from each other.
The third use is as summative assessment activities. This makes the assessments in the class be authentic problems that the students can demonstrate what they have learned while solving this situation. Some activities are from the SIMIODE website, some are from other sources, and some are developed by the presenter. Come see how activities are used in these different modalities.

- (Room 1) Nicholas Fortune, Western Kentucky University, Bowling Green KY USA; Karen Keene, Embry-Riddle Aeronautical University, Daytona Beach FL USA; Chris Rasmussen, San Diego State Univesity, San Diego CA USA *Inquiry Oriented Differential Equations (IODE): A Student-Centered Modeling Curriculum*

  **Abstract:** In this talk, we provide an overview of the Inquiry-Oriented Differential Equations (IODE) curriculum, focusing on both the curricular design as well as the underlying research philosophy. IODE is a first course in differential equations focused on understanding of the big ideas in first order, second order, nonlinear, and systems of differential equations. The course is designed as a full semester course and topics covered include solving ODEs; numerical, analytic and graphical solution methods; solutions and spaces of solutions; linear systems; linearization; qualitative analysis of both ODEs and linear systems of ODEs; structures of solution spaces.
  Our use of the term inquiry aspires to aligns with the four pillars of Inquiry Based Mathematics Education (IBME) (Laursen and Rasmussen, 2019): students engage deeply with coherent and meaningful mathematical tasks, students collaboratively process mathematical ideas, instructors inquire into student thinking, and instructors foster equity in their design and facilitation choices. IODE is an open-source curriculum available on CODEE's website and at https://iode.sdsu.edu.

  Reference
  1. Laursen, S. L., and C. Rasmussen, C. 2019. I on the prize: Inquiry approaches in undergraduate mathematics. *International Journal of Research in Undergraduate Mathematics Education*. https://doi.org/10.1007/s40753-019-00085-6.

## Day 2 - 4:30 PM–4:55 PM: Modeling in Undergraduate Research - I

- (Main Room) Eric Stachura, Kennesaw State University, Kennesaw GA USA *A different route to success: passing by differential equations*

  **Abstract:** In this talk, I will discuss the dynamics of time spent mentoring a particular undergraduate student. While the differential equations project we studied didn't result in an any novel result, I will explain how the experience led her to another professor to work on more discrete problems, and eventually led her to graduate school to pursue her Ph.D. in Mathematics.
  This talk will include both the technical aspects of the differential equations project as well as the more informal discussion on this particular student's trajectory. Although not a success in the classical sense (i.e. peer reviewed publication as a result), I will argue this project should still be considered a success, and end with a general discussion on what failure may (or may not!) look like in mathematics.

- (Room 1) Michael A. Karls, Ball State University, Muncie IN USA *A Two-Dimensional Groundwater Flow Modeling Project*

**Abstract:** The purpose of this project is to derive and investigate a mathematical model for two-dimensional flow of groundwater. This model consists of a partial differential equation known as the two-dimensional groundwater flow equation as well as appropriate boundary conditions and initial data. After finding analytical and numerical solutions to the resulting initial value – boundary value problem, we will compare our models via an example implemented in Mathematica. The numerical computations are implemented in Excel. This project came about as a result of an Undergraduate Honors Thesis project at Ball State University.

- (Room 2) Edem Fiatsonu, Texas A&M University, College Station TX USA *Effectiveness of Fluralaner Treatment Regimens for the Control of Canine Chagas*

  **Abstract:** Canine Chagas disease is caused by the protozoan parasite Trypanosoma cruzi and transmitted by insect triatomines called kissing bugs. The agent can cause cardiac damage and long-term heart disease and death in humans, dogs, and other mammals. We developed compartmental vector-host models of *T. cruzi* transmission between triatomine and dog populations accounting for the impact of seasonality and triatomine migration on disease transmission dynamics.
  We considered a single vector-host model without seasonality, model with seasonality, and a spatially coupled model. We used the models to evaluate the effectiveness of the insecticide fluralaner with different treatment regimens for reducing *T. cruzi* in different transmission settings. In low and medium transmission settings, our model showed a marginal difference between the 3-month and 6-month regimens for reducing *T. cruzi* among dogs. The difference increases in the presence of seasonality and triatomine migration from sylvatic transmission settings.
  In high transmission settings, the 3-month regimen was substantially more effective at reducing *T. cruzi* in dogs than the other regimens. Our study showed that an increased migration rate reduces fluralaner effectiveness in all treatment regimens, but the relative reduction in effectiveness is minimal during the first years of treatment. However, if an additional 10% or more of triatomines killed by dog treatment were eaten by dogs, treatment could increase *T. cruzi* infections in the dog population at least during the first year of treatment. Our analysis shows that in peridomestic transmission settings, treating dogs every three to six months may reduce *T. cruzi* infections in dogs.

## Day 2 - 5:00 PM–5:25 PM: Get to Know Colleague Attendees

We provide Break Out rooms with 5 attendees assigned randomly so attendees can get to know some other attendees and exchange interests.

## Day 2 - 5:30 PM–5:55 PM: Model Examples

- (Mail Room) Sami Kanderian, WikiModel LLC, Germantown MD USA *Implementing a Multicompartment Pharmacokinetic Drug Delivery Model as a System of Ordinary Differential Equations*

  **Abstract:** A pharmacokinetic compartment describes a space in the body which a drug appears to occupy but may not necessarily correspond to any specific anatomical or physiological space. However, the simulation of multicompartment models have adequately described the concentration of a drug measured in a particular space.

  Each compartment is represented by an Ordinary Differential Equation (ODE) connected to one or more other compartments whereby arrows represent the mass transfer to, from, or between them. The left-hand side of the ODE represents the rate of change of the drug

in the compartment. The right-hand side represents the general mass balance formula of positive inflows and negative outflows of the drug. Each arrow exiting is formulated by a negative rate constant of the drug leaving the compartment multiplied by the amount of the drug in the compartment. Each arrow entering is formulated by the rate constant coming in multiplied by the amount of the drug in the compartment it is coming from.

If the drug is coming from outside the body instead of another compartment, the delivered amount is formulated as a non-zero initial condition or an input disturbance to the ODE in the case of multiple impulse doses or changing continuous flow rates. The model output of one of the compartments is fit to experimental concentrations sampled from one area of the body to identify the rate constants of the model. Subsequently the model and identified parameters are used to optimize a dosing strategy to achieve a desired drug concentration profile.

- (Room 1) Jacob Duncan, Winona State University, Winona MN USA *How High? Modeling Free Fall with Air Drag*

  **Abstract:** Most projectile motion and free fall models are based on the assumption that gravity is the only force acting on the object. In this talk, I discuss a SIMIODE Modeling Scenario centering around the construction of a free fall model that accounts for the force of air drag. In the module, students develop, solve, and analyze a second order nonhomogeneous differential equation model for free fall which incorporates air resistance.

  Students solve the model using two different methods – reduction of order and separation of variables, and method of undetermined coefficients. Using the solution, students derive an expression for the terminal velocity of the object as well as a prediction of the maximum height of the object (assuming is is fired directly upwards). The model is then parameterized for a Nerf dart by an experiment performed by students. The terminal velocity and muzzle velocity of the dart is measured using video frames of the dart's motion. Finally, the model is validated by an experiment wherein students fire their darts upward and measure the assent time for comparisons with their predictions.

- (Room 2) James T Sandefur, Georgetown University, Washington DC USA *Modeling Population Growth and Sustainable Harvesting*

  **Abstract:** We use students' understanding of rational and exponential functions to develop several different differential equations that model the growth of density dependent populations. Particularly, we use the concavity of functions to separate models of species with contest competition from those with scramble competition. We then discuss the advantages of using phase-line analysis over finding solutions to study these differential equations. Finally, we easily integrate constant effort harvesting into the models to development general principles for sustainable harvesting. The techniques used are all appropriate for students with one semester of calculus and lead to some engaging and surprising results.

## Day 2 - 6:00 PM–7:30 PM: Meal Break

## Day 2 - 7:30 PM–7:55 PM: And Now for Somethings Completely Different . . . AND Good!

- (Main Room) Kyle Allaire, Worcester State University, Worcester MA USA and Lisa Naples, Macalaster College, Saint Paul MN USA *Organizing a SIMIODE Sponsored AMS Special Session at JMM 2023 – How to Do It*

  **Abstract:** In this talk, we discuss the process of applying for and organizing a SIMIODE sponsored AMS Special Session at the Joint Mathematics Meetings 2023. Topics of discussion include application requirements and deadlines, organizer duties before and during the session, and the benefits of organizing a session to the organizer(s) and larger mathematics community.

- (Room 1) Debasmita Mukherjee, Nilkamal School of Mathematics, SVKM's NMIMS, Deemed to be University, Mumbai INDIA *Mathematical Analysis of a Dynamical Model of Mild Atherosclerosis*

  **Abstract:**Atherosclerosis is a chronic inflammation caused by the accumulation of plaque in the intima. The current theoretical investigation discusses the formation of atherosclerotic plaques arising from blood flow and the stability of model systems characterized by interaction between many cellular species in the surrounding vascular region. The biochemical processes behind the formation of atherosclerotic plaques include interactions between many cellular species such as low density lipoprotein, free radicals, chemoattractants, monocytes, macrophages, T-cells, smooth muscle cells, foam cells and collagen.
  Considering all these complex phenomena, a suitable mathematical model was developed to describe the onset of atherosclerotic plaques in the arterial lumen by the concentration of the most relevant elements of atherosclerotic obstruction by a system of non-linear ordinary differential equations (ODEs).
  In addition to an in-depth study of model, special emphasis is placed on reduced model systems that are sufficiently relevant to existing systems that adhere to the quasi steady state approximation (QSSA) theory. Both local and global stability were conducted and bifurcation analysis is performed for the reduced model systems. A numerical analysis of this model system reveals the effect of a few key parameters of the model, which can be developed to devise a diagnostic strategy to control the dynamics of the disease.
  We will be explaining the disease formulation and evolution at first and explain the ODE model step by step.

- (Room 2) Luis Felipe Ramanzini, Matthew Baker, and Gabriella Rodriguez, Florida Polytechnic University, Lakeland FL USA *SCUDEM Outstanding Award Team: People Ruin Everything*

  **Abstract:** The circle of life is one of nature's grandest innovations, which has remained untouched for millennia. With the introduction of urban society, many animals have been hunted down; still more have been domesticated, bred to be docile and complacent. For Problem C of the SCUDEM challenge, we evaluated the long-term effect that human involvement has on prey and predator species. We also aimed to answer the question of whether survival skills lost during domestication can be regained. After thorough research, we opted to study pigeons and hawks. They were a realistic example to base our model off of, since their feral nature and dependence on humans has been documented in many large cities like Chicago.
  We used the Lotka-Volterra model as our foundation due to the fact that it was already intended to monitor changes in population growth for two species which are dependent

on each other. By understanding the logic behind this model, we could modify its constant coefficients and general structure to reflect the introduction of humans into the food chain. We also made assumptions that simplified the model, using a constant number for the human population and implementing a piecewise function to split the model into three sections.
Our findings showed that the two populations remained stable until the humans arrived; at this point, many hawks died off and pigeon population boomed. After the humans left, both populations reached a diminished state of equilibrium, which indicates that antipredator traits are affected by humans, but could recover.

## Day 2 - 8:00 PM–8:25 PM: Modeling in Undergraduate Research - II

- (Main Room) Tahmineh Azizi, University of Wisconsin-Madison, Madison WI USA
  *Using Fractal Geometry to Quantify the Complexity of Nature*

  **Abstract:** For the first time in 1983 Mandelbrot introduced" Fractal" to the world. Fractals are known objects with self-similarity in different scales, i.e., if we look closer at the fractal set, we see a similar geometrical pattern which repeats infinite times to build a fractal object. Mandelbrot fractal geometry could successfully extract mathematical frameworks to model self-similar patterns in nature. One the most fascinating findings in fractal geometry were discovering the fractal patterns inside body. Even though a fractal is, by definition, an infinite pattern and cannot be measured, the Koch snowflake lets us see that even though the perimeter of a fractal is infinite, the area is not. The fractal dimension (FD) is a quantitative parameter that has been extensively used to analyze the complexity of structural and functional patterns and it describes a natural object in a better way than Euclidean dimension does. In this study, we will employ the fractal theory to quantify the complexity of different objects in biology, geology, and physiology. A quantitative analysis commonly known as the Fractal Dimension (FD) analysis has been carried out to illustrate the fractal complexity of these natural examples. Our finding shows that the fractal theory in dynamical systems can be used as a mathematical model to further analysis and classification of different real-world objects and can be considered as a framework to compare the complexity of these examples and useful tool to differentiate between their patterns.

- (Room 1) Viktoria Savatorova, Central Connecticut State University, New Britain CT USA *Optimal Control Applied to Blood Glucose Level Regulation in Diabetes Patients*

  **Abstract:** A simplified system of two linear differential equations with constant coefficients is used to model blood glucose regulatory system in diabetes patients [1]. We employ a nonlinear least squares method to fit the data from the glucose tolerance test into the model and determine parameters of the system. Optimal control [3] allows to find the insulin injection level that minimizes the deviation of blood glucose concentration from the desired value while avoiding usage of large amount of insulin.

  References:
  [1] Eugene Ackerman, Lael C. Gatewood, John W. Rosevear, George D. Molnar. 1965. Model Studies of Blood-glucose regulation. *Bulletin of Mathematical Biophysics*. 27:21 - 37.
  [2] Martin Eisen. 1988. *Mathematical Methods and Models in the Biological Sciences*. Prentice Hall, Englewood Cliffs, New Jersey.

- (Room 2) Madison Utterback and Christiana Beard, Intercollegiate Biomathematics Alliance, Illinois State University, Normal IL USA *Modeling the Outcome of Patients with Ischemic Hepatitis*

  **Abstract:** Ischemic Hepatitis (IH) is a liver injury preceded by hepatocyte death. The only way to diagnose this disease is to eliminate the possibilities of all other liver injuries currently. To combat this issue, our goal is to explore computational models that are able to predict the outcome in terms of death or survival of a person who suffers from IH based on various biomedical indicators such as: creatinine peak, international normalized ratio peak, aspartate aminotransferase peak, alanine transaminase peak, and bilirubin peak. The real patient data was collected across multi centers from the US by the Acute Liver Failure Study Group. We clean, process, and analyze the data utilizing classification models like logistic regression and regression tree method, including BART, to predict the outcome of the patients suffering from IH. We then apply SMOTE and boosting techniques to improve the prediction accuracy. Obtaining the sensitivity and specificity of the testing methods helps us compare the outcome to determine the best model.

## Day 2 - 8:30 PM–8:55 PM: Modeling in Undergraduate Research - III

- (Main Room) Chris McCarthy, Borough of Manhattan Community College, CUNY, New York NY USA *Student differential equation modeling projects*

  **Abstract:**In this talk we will share a number of different student projects involving differential equation models.

- (Room 1) Aditya Dalal, Georgia Institution of Technology, Atlanta GA USA *Using Differential and Multivariable Calculus to Model the Success of Energy Transition Policies*

  **Abstract:** This research uses a novel way to evaluate the success of renewable energy policy by comparing its targets to the maximum potential success of a policy according to models derived from available data. A sample analysis was conducted to evaluate India's 2030 energy targets and it was found they were only 65.2% optimal. The evaluation is centered on the fact that gradients represent the maximum magnitude of directional derivatives. If the magnitude of directional derivatives represents the rate of change of positive effects of the policy on society, the gradient represents the rate of change of positive effects of an optimum policy on society. These can therefore be compared and an index or percentage of optimality can be obtained. Other results related to energy import dependency can also be simply derived.
  This method can also have applications in other types of policy evaluation and there is also scope for modelling political inefficiency and corruption to a high accuracy using this method, as discussed in the end of the poster. It can also be basis for a new machine learning based algorithm that can evaluate policies and governments better. The method of evaluation used is novel and represents the fact that differential calculus has applications for policy evaluation, a topic seemingly divorced from the applications of calculus. It also shows how a simple observation such as the relation between gradients and directional derivatives can open so many doors in terms of application in a rea-world scenario.

## Day 2 - 9:00 PM–9:45 PM: (Main Room) MathBowl

Paul Fonstad, Mathematics, Franklin College, Franklin IN USA
MathBowl Challenge -- Download and Print Blank Answer Sheet.

Experience the fun and challenge of answering mathematical content and trivia in a self-scoring activity for the pure joy of knowing what you know and what you don't know. See video from SIMIODE EXPO 2021.

## Day 2 - 9:45 PM–until: After Hours Small Group Discussions on *ChatGPT*

## Day 2 - Free Time

The conference platform will be open for informal self-directed conversations and Zoom meetings.

# Day 3: 12 February 2023 (Eastern US Time)

## Day 3 - 12:45 PM–1:00 PM: Opening Greeting

## Day 3 - 1:00 PM–1:25 PM: Special Topics within Differential Equations Modeling Courses

- (Main Room) Carey Witkov, Embry-Riddle Aeronautical University - Worldwide campus, Daytona Beach FL USA *Network Diagrams (e.g., Flow Graphs and Block Diagrams) in Understanding the Structure and Behavior of Differential Equations*

  **Abstract:** Unlike graphical methods (e.g., phase plots and slope fields) that display differential equation behavior using coordinate axes, network diagrams (e.g., flow graphs and block diagrams), popular in control engineering, are coordinate-free visual methods that reveal structure and interconnections (e.g., feedback loops) within differential equations themselves. This talk introduces network diagrams for ODEs with linear and nonlinear (e.g., Duffing equation) examples. In addition, demonstrations of running network diagram models in software will be provided.

- (Room 1) Kurt Bryan, Rose-Hulman Institute of Technology, Terre Haute IN USA *Cruise Control*

  **Abstract:** Control Theory is an important part of our technology, and PID ("Proportional-Integral-Derivative") control is one of the most common classes of control algorithm. This type of control is often applied to physical systems that are governed by differential equations. I'll show a simple application that my students have enjoyed, designing a "cruise control" for an automobile. This application also illustrates a nontrivial application of the Laplace transform, beyond solving ODEs.

- (Room 2) Boyan Kostadinov, New York City College of Technology, CUNY, Brooklyn NY USA *Hitting a Stationary Target by Firing a Projectile from Different Angles*

  **Abstract:** In this talk, we consider an inverse range problem for projectiles in a model with air resistance whose origins are attributed to Niccolo Tartaglia, a self-educated mathematics teacher, engineer, and surveyor from the 16th century Republic of Venice. His writings had a big influence on Galileo who owned "richly annotated" copies of Tartaglia’s works on ballistics. Tartaglia was selling mathematical advice to gunners and one of his findings was that the maximum (optimal) range of a projectile fired from a cannon can be achieved by directing the cannon at a 45 degree angle relative to the horizon. A more curious claim attributed to Tartaglia was that any given suboptimal range can be achieved by firing the projectile at two different angles. Thus, the inverse problem can be stated as finding all firing angles that lead to the same suboptimal range. We develop a computational framework using R and RStudio for this inverse range problem by considering a model of air resistance where the air drag is proportional to the velocity. We will discuss some pedagogical issues related to the mathematical and technology sides of the project, as well as further extensions to more general models of air resistance where the air drag depends on some power of the velocity.

## Day 3 - 1:30 PM–1:55 PM: How to Get Started with Modeling in a Course

- (Main Room) Thomas Mussmann, United States Military Academy, West Point NY USA *Modeling in Depth*

**Abstract:** We discuss the West Point modeling process aimed at enabling students to generate a model on their own, most clearly tested by our end of semester project. We noticed that by expecting students to do problems with lots of models that have similar examples in the book, we lead them to closely mirroring formulas from a book without understanding or explaining why. We use Bloom's Taxonomy to help us explore the problem and propose changes to the way we teach model building.

- (Room 1) Tova Brown, Wisconsin Lutheran College, Milwaukee WI USA and Brody Johnson, Saint Louis University, Saint Louis, Missouri, USA *Pullback Cars and Pop Cycles: Vehicles for a First Modeling Experience*

  **Abstract:** This presentation will outline recently developed modeling scenarios that examine the velocity and distance traveled of specific toys. Instructors have the option to use included data or guide their students through a hands-on modeling experience in which data is extracted from cellphone videos of the toy(s) in motion.

## Day 3 - 2:00 PM–2:25 PM Outreach efforts for mathematics.

- (Main Room) Tim Pennings, Mentor - Prison Math Project and Walker Blackwell, Co-Founder - Prison Math Project *Creating Justice Through Differential Equations*

  **Abstract:** The Prison Math Project (PMP), Directed by Christopher Havens, believes that the rehabilitation of our nation's incarcerated population into a life of desistance from crime is a necessary factor in the service of Justice. PMP uses the transformative power of mathematics via the culture and practice of the mathematics community to inspire its incarcerated participants into a rehabilitative process of personal growth and change. This presentation concerns creating Justice through the teaching and learning of mathematics in the restrictive environment of prison, and how the mathematics community can help reach this goal. The Prison Mathematics Project aims to develop a new understanding of the role of mathematics in self-identity and desistance among our participants by providing knowledge, instilling the idea of community and culture, and establishing network connections so that participants can become empowered to self-rehabilitate through the engagement of mathematics.

- (Room 1) Victor Donnay, Bryn Mawr College, Bryn Mawr PA USA *Community Based Projects for a Course on Math Modeling and Sustainability.*

  **Abstract:** For the past decade I have been teaching a course on Math Modeling and Sustainability. As part of the course, students work in teams to assist a community partner in exploring a sustainability issue of interest. For example, what are the benefits and pay-back time of purchasing solar panels for our township building or converting our college's facilities fleet to electric vehicles. With the newly enacted Inflation Reduction Act, there will be increased opportunities for non-profit organizations to undertake renewable energy projects and for our college math students to support these efforts. In this session, we will discuss the logistics of organizing and implementing these community-based projects, benefits to students of these real-world projects and lessons learned.
  Reference:
  1. Victor Donnay. 2013. Using sustainability to incorporate service-learning into a mathematics course: a case study. *PRIMUS* Special issue on Service Learning 23(6): 519-537.

## Day 3 - 2:30 PM–2:55 PM: Sample Classes Discussed and Demonstrated

- (Main Room) Li Zhang, The Citadel, Charleston SC USA *Simulation and Modeling Blue Whale and Krill Populations*

  **Abstract:** In this talk we present how we use the SIMIODE Modeling Scenario 6-025 Whales and Krill to teach our students a system of differential equations through modeling activities. Students are asked to use a software to observe qualitative behavior in a simulation of a predator-prey (blue whale and krill) model. Through modeling activities, students are expected to use the numerical and graphical methods to observe the qualitative behavior of the predator and prey population.

- (Room 1) Norma Miller, Universidad Tecnológica de Panamá, Campus Metropolitano Víctor Levi Sasso, Panamá City PANAMA and Willian Alejandro Aristizabal Bossa, Universidad Santo Tomás, Villavicencio COLUMBIA *An Experience in Interuniversity/International Collaboration on Teaching a Modeling Scenario*

  **Abstract:** This talk summarizes an experience that took place during the 2022 academic year as part of a COIL (Collaborative Online International Learning) initiative between the Technological University of Panamá (Chiriquí campus) and the Santo Tomás University (Colombia, Villavicencio campus). The course was undergraduate Ordinary Differential Equations, and the joint project consisted of implementing SIMIODE's Modeling Scenario 1-015-Torricelli project, modeling the height of a falling column of water in a right circular cylinder being emptied through a small hole on its lower lateral side.
  The two professors, one familiar with, the other new to SIMIODE, met online twice to design the experience. A third meeting included the students, who were introduced to their teammates. During this session one professor presented the theoretical background for the model, while the other explained its implementation (resources and work dynamics).
  The results for the students were a mixed bag, in part due to special circumstances of one of the groups, along with restrictions imposed by COVID-19 on instruction. However, the professors developed a good working relationship and look forward to a continued joint implementation of modeling scenarios with their ODE students.

## Day 3 - 3:00 PM–3:25 PM: Engaging Students Early and Close to Cognate Discipline Courses

- (Main Room) Yanping Ma, Loyola Marymount University, Los Angeles CA USA *Engaging Students with Hands-on Activities on the First Day of Differential Equations Class*

  **Abstract:** Teaching ordinary differential equations (ODE) classes using a modeling-first approach is crucial for student understanding. In this talk, we will experience a hands-on activity for the first day of an ODE class, adapted from a MINDE workshop by SIMIODE. The focus will be on creating an intuitive discussion flow for students to grasp the power of ODEs. Using M&M beans, dorm maps, and cups, students will study the spread of a common cold in a dorm, practicing data collection, analysis, connection proposal, and model selection to reinforce ODEs real-world applications.

- (Room 1) Mark Nelson, University of Wollongong, Wollongong NSW AUSTRALIA *Snap, Crackle and Pop: Models from the Field of Reaction Engineering*

**Abstract:** Sometimes, we give students a real-world problem and ask them to develop a mathematical model. Other times, we give students an existing model. Sometimes we use the physical scenario underpinning the model to provide context whilst we test their mathematical skills. Sometimes we want them to explore the application of the model to the physical scenario. Reaction engineering is an area of chemical/industrial engineering dealing with the behaviour of chemical reactors. It lays at the intersection of physical chemistry, chemical engineering, and applied mathematics. These models can be readily used in applied mathematics subjects, even when the student cohort are not chemical engineers. I discuss a variety of reaction engineering examples which can be used in a variety of subjects on differential equations/mathematical modelling.

## Day 3 - 3:30 PM–4:25 PM: Authoring a Modeling Textbook - Why and How

- (Main Room) Timothy Pennings, Calvin University, Grand Rapids MI USA; Glenn Ledder, University of Nebraska-Lincoln, Lincoln NE USA; Kurt Bryan, Rose-Hulman Institute of Technology, Terre Haute IN USA; Joseph DiStefano III, University of California, Los Angeles CA USA *Authoring a Modeling Textbook - Why and How*

  **Abstract:** We will hear from authors about their efforts to create a textbook rich in applications of mathematics and modeling. What does it take to author a book, to share in the passion and joy in producing a guide for students and teachers, to relate the experiences that are captured in the entire process of idea to authoring and editing to production to marketing and engaging. A natural question is "Why?" or "To what end?" Some materials are OER, some are commercial. That is not the issue in this panel conversation. Nor is this about "competition," for each of the efforts represented has a slightly different audience and purpose, as will be defined more precisely in the discussions.
The panelists will share some lessons learned in their process to produce a contribution to the learning and teaching of mathematics and it rich applications. Who knows, you might come away thinking, “I would like to organize my teaching ideas and share it with others, not with an article, but with a textbook!”
  References
  1. Bryan, Kurt. 2021. *Differential Equations: A Toolbox for Modeling the World* SIMIODE: Chardon OH USA
  2. DiStefano, Joseph, III. 2023. *Dynamic Biosystem Modeling and Simulation Methodology: Integrated and Accessible*. Third Edition: Color Enhanced Education Version. Academic Press. Cambridge MA USA.
  3. Ledder, Glenn 2023. *Mathematical Modeling for Epidemiology and Ecology* Springer: SWITZERLAND. Forthcoming

## Day 3 - 4:30 PM–4:55 PM: Breakout Room to Discuss Important Issues

- (Main Room) Yanping Ma, Loyola Marymount University, Los Angeles CA USA *Impact of ChatGPT and AI Software*

  **Abstract:** An open discussion on how *ChatGPT* can impact the way we teach mathematical modeling and mathematics, in general. Consider this post How ChatGPT can help in Education? Further, see comments in LinkedIn on ChatGPT in ODE coursework.

## Day 3 - 5:00 PM–5:25 PM: Applications in Biology and Engineering

- (Main Room) Hillel Chiel, Case Western Reserve University, Cleveland OH USA *Teaching Modeling to Biology Undergraduates*

  **Abstract:** Mathematical modeling and computer simulation are increasingly important tools for understanding biology. Most undergraduates who major in biology do not have strong backgrounds in mathematics or computer simulation, and are often very unenthusiastic about either area. Since many new research and job opportunities are available to biologists who know mathematics and can do computer simulation, giving students access to these skills is critical. An effective approach is to give students basic skills, and then ask them to apply those skills to an actual biological modeling problem by reconstructing and extending a model that has been published in the technical literature.

  Encouraging students to choose models that genuinely interest them - whether the models focus on flu or COVID epidemics, new treatments for cancer, changes in pollinator density, metabolism of alcohol, neural circuitry, development of the Drosophila embryo, or biomechanical models of muscle, to name just a few examples - strongly motivates students to master and apply foundational material to a significant contemporary biological problem. Reconstructing an existing model allows the students to check whether they obtain results similar to those that have been published, and extending the model gives them a chance to directly participate in new research.

  In this presentation, I will describe a course, Dynamics of Biological Systems, that teaches students key skills in mathematics and computer simulation, and share some of the pedagogical issues that need to be dealt with to help students gain confidence and master the material.

- (Room 1) Mohamed Hafez, University of California, Davis CA USA *Numerical Solutions of Nonlinear Differential Equations for STEM College Education*

  **Abstract:** In engineering applications, most of the governing differential equations are nonlinear. Moreover, analytical solutions are very rare. Therefore, numerical solutions using computers are essential. Examples of nonlinear initial, boundary, and eigenvalue problems will be presented, covering: Dynamics and Oscillations, Fluid and Gas Dynamics, and Solid and Structural Mechanics.

  In particular, the following problems will be considered: A Falling Ball in Gas, where the drag is proportional to the square of the speed. A related problem is the trajectory of a bullet, taking into account the resistance of the air. Also, the Two Body Problem of Orbital Mechanics and the Spin Stabilization of a Rocket or a Satellite as well as Oscillations with nonlinear damping and stiffness will be offered. Next, the solution of Blasius Equation for incompressible laminar flow over a flat plate without pressure gradient, as well as compressible inviscid flow in a convergent/divergent nozzle, with and without shock waves will be presented. Finally, the large deflections of a cable under tension, a beam under bending and a column under buckling will be discussed

  All the problems are discretized using second order finite differences. Standard solution techniques are used. For example, fixed point iteration and Newton linearization, shooting methods as well as implicit time integration for stiff equations. All the examples are chosen from special projects for undergraduate engineering students at UC Davis.

- (Room 2) Royce Arockiasamy, Henry Bui, and Adi Krish, Georgia Institute of Technology, Atlanta GA USA *SCUDEM Outstanding Award Team: Humans Don't Deserve the World -- Modeling the Introduction of Humans to a Predator-Prey System*

  **Abstract:** In the Fall of 2022, our team competed in SCUDEM VII hosted by SIMIODE, where we received the highest distinction - Outstanding Award. Our goal was to study humans' effects on predator-prey populations when they populate an area. In this talk, we would like to go over how we prepared for and solved Problem C, present our equations and their derivations, explain our models, go over some of the feedback from the judges, and talk about how the SCUDEM challenge benefited us as students. See the Outstanding Team Video video posted on SIMIODE's YouTube Channel.

## Day 3 - 5:30 PM–5:55 PM: Modeling - The Broader Viewpoint

- (Main Room) Dina Yagodich, Frederick Community College, Frederick MD USA *My Journey from Electrical Engineer to Teaching Diff Eq with Candy*

  **Abstract:** Looking back on 19 years of teaching, Dina has gone from throwing knowledge at students during a 2.5 hour once a week math class to flipping the classroom, focusing on the why before the how, and letting students be active participants. There have been two major turning points in her career that have altered her teaching methodology. One was, like it was for many others, COVID. The other was a session at a JMM conference in 2014 when she attended a 4:15 p.m. talk by Brian Winkel entitled "Modeling Scenarios and Strategies in Differential Equations Course." Listen to Dina's journey in teaching pedagogy and how she approaches classes like Differential Equations, among others.

- (Room 1) Anuj Mubayi, Center for Collaborative Studies in Mathematical Biology, Illinois State University, Normal IL USA Real World Evidence Solutions, IQVIA, USA; 4820 Emperor Blvd, Durham NC USA; and Kalam Institute of Health Technology, Government of India, Visakhapatnam INDIA. *Multiresolution Modeling and Evidence Generation: Implications from Social Issues to Precision Health*

  **Abstract:** Covid-19 is having a profound impact on our society. Across the landscape of health and social sciences, the response in future will going to see huge transformation on various dimensions including empirical evidence, methodology, and experiences based on multiple stakeholders. Dr. Mubayi will use his own research to show how transformation are shaping the future of education and research by incorporating multidimensional evidence-based research with the aim of enhancing personal health and needs in real time. Integrated modeling and evidence-generation process are being used to connect siloed functioning of disciplines. His talk will highlight some data-driven-critical modeling framework from various applications that leverage advanced modelling techniques and diverse community.

## Day 3 - 6:00 PM–6:15 PM: Farewell, Closing, and Evaluation Survey

The conference platform will stay open until 11:00 PM to give everyone a chance to visit in small groups, reunite with colleagues, and talk over interesting ideas with other conference participants.